IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	:	**Mail Stop Appeal Brief - Patents**
John MACNEIL et al.	:	Group Art Unit: 1762
Serial No. 09/914,204	:	Examiner: Elena Tsoy
Filed February 20, 2002	:	

A METHOD OF PROCESSING A POLYMER LAYER

APPELLANT'S BREIF

U.S. Patent and Trademark Office
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

Sir:

In connection with the above-identified application, please enter this Appellant's Brief is in support of Applicant's appeal before the Board of Patent Appeals and Interferences.

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REAL PARTY IN INTEREST

The real party in interest is the assignee of record of the application, namely, Trikon Holdings Limited, located at Coed Rheyden, Ringland Way, Newport, Gwent, NP62Ta, Great Britian.

RELATED APPEALS AND INTERFERENCES

There are no prior or pending appeals, judicial proceedings or interferences known to the Appellant which may be related to, directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

STATUS OF CLAIMS

Claims 1, 3, 5 and 10-26 are pending in the application and all stand rejected. No claims are allowed.

Claims 1, 3, 5 and 10-26 are the claims appealed.

Claims 2, 4 and 6-9 have been cancelled.

STATUS OF AMENDMENTS

There have been no amendments filed subsequent to final rejection.

SUMMARY OF CLAIMED SUBJECT MATTER

General

The invention of the appealed claims is generally directed to the processing of dielectric polymer layers having Si-C bonds. As is well-know in the semiconductor arts, dielectric polymer layers having organic components exhibit low-k (low dielectric constant) properties.

See, for example, the EVIDENCE APPENDIX which contains an extract from U.S. Patent No. 6,100,184. Included in this extract is a brief discussion contrasting high-k SO_2 dielectric layers and low-k organic polymer layers.

However, as described at page 2, lines 4-6, of the present specification, low-k organic polymer layers are prone to cracking. Thus, one objective of the invention is to minimize cracking of such layers. According to embodiments of the present invention, cracking is reduced by subjecting a low-k organic polymer layer to the combination of heat and hydrogen plasma in the manner defined by the appealed claims.

Claim 1

The subject matter of appealed claim 1 is generally described in the background portion of the present specification, and detailed experimental results corresponding to the subject matter of appealed claim 1 are presented in the detailed description portion of the present specification.

"a method of processing a polymer layer including Si-C bonds"

Claim 1 is not concerned with the manner in which the Si-C polymer layer is initially formed. Typically, however, such layers are formed by reaction of methyl silane and hydrogen peroxide in a chemical vapor deposition (CVD) apparatus. See, for example, page 2, lines 17-18; page 6, lines 3-7, of the present specification.

"heating the layer to desorb moisture and harden the layer and exposing the layer to a hydrogen plasma during the heating process"

According to claim 1, the Si-C polymer layer is simultaneously subjected to heating and hydrogen plasma exposure. In other words, the heating and hydrogen plasma exposure overlap for at least some period of time. The heating desorbs moisture and hardens the layer, while the hydrogen plasma is effective in reducing cracking of the layer during heating.

"wherein the polymer layer includes carbon subsequent to said heating and exposing"

This limitation is included to clarify that the aim of the present invention is to process a polymer layer having Si-C bonds (i.e., low-k polymer layers – see dependent claim 3 as well). See, for example, page 1, lines 2-6, of the specification.

"wherein the layer is supported on an electrode and the plasma is at least partially maintained by an RF power source connected to the electrode"

It has been found that the invention is especially effective when the platen electrode is driven by RF power. See, for example, the table at page 8, line 4. As is well-understood by those of ordinary skill, an RF-driven platen electrode substantially increases the energy with which the plasma ions are impacted on the surface of a substrate or wafer supported by the platen.

Independent Claim 21

Claim 21 includes the same limitations as discussed above in connection with independent claim 1. In addition, claim 21 defines a thickness of the polymer layer as being in a range of 7,000Å to 9,000Å. See, for example, the paragraph bridging pages 9 and 10 of the present specification.

Independent Claim 22

Claim 22 is similar to claim 1, except that claim 22 recites the hydrogen plasma being generated in a Reactive Ion Etching (RIE) mode. The RIE mode (which inherently includes an RF driven platen), was found to be particularly desirable in terms of maintaining a low-k value. See, for example, page 9, lines 10-13, of the present specification.

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The grounds of rejection presented for review are as follows:

1. Whether claims 1, 3, 5, 10-26 are unpatentable under 35 U.S.C. ¶103 over *Li* (US 6,383,951) in view of *Tamura et al.* (US 5,897,923) and *Tsukune et al.* (US 5,314,724); and
2. Whether claims 1, 3, 5 and 10-26 are unpatentable under 35 U.S.C. ¶103 over *Tsukune et al.* (US 5,314,724) in view of *Domoto et al.* (US 6,354,008), *Li* (US 6,383,951) and *Tamura et al.* (US 5,897,923).

ARGUMENT

I. GENERAL OBSERVATIONS

The Appellant has carefully considered the Examiner's comments contained in the Office Action dated July 15, 2006. Unfortunately, however, the line of reasoning set forth in the Office Action is difficult (and sometimes impossible) for Appellant to follow, and as a result, it is unclear to Appellant the exact manner in which the Examiner is proposing to modify and combine the cited references. (As examples only, each paragraph of the Office Action containing the phrase -- "it is the Examiner's position" -- is not well-understood.) The arguments presented here are responsive to Appellant's "best guess" as to the nature of the Examiner's rejections.

What is clear, however, is that the rejections are the result of selective picking and choosing among unrelated elements (or processes) of the cited references, and then attempting to combine these elements to read on the present claims. The Examiner has combined the references without regard to the stated objectives of the references – in other words, without regard to teachings <u>as a whole</u> of the cited references.

II. LI IN VIEW OF TAMURA ET AL. AND TSUKUNE ET AL.

Claims 1, 3, 5, 10-26 stand rejected under 35 U.S.C. ¶103 as being unpatentable over *Li* (US 6,383,951) in view of *Tamura et al.* (US 5,897,923) and *Tsukune et al.* (US 5,314,724).

<u>Li</u>

Li is generally directed to the formation of a low-k interlevel dielectric (ILD) layer, and in particular, *Li* is directed to improving upon the "conventional" process illustrated in FIG. 1 thereof.

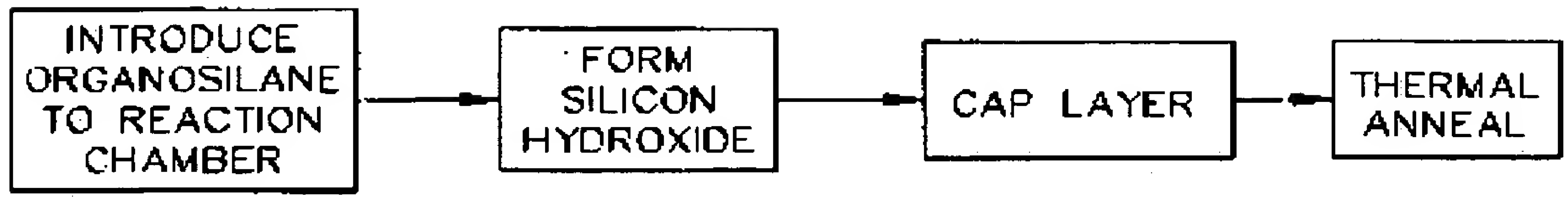

FIG. 1
(PRIOR ART)

Referring to FIG. 1, *Li* teaches that an organosilane (e.g., SiH_3CH_3) is made to react with an oxidizing agent to form a layer of silicon hydroxide containing carbon. This silanol/carbon layer is then treated to drive off water, resulting in a stable low-k dielectric layer. Col. 3, lines 46-52.

Li further teaches that the low-k dielectric layer is conventionally subjected to a post-deposition treatment in which a cap layer is deposited thereon. This treatment includes formation of the cap layer by plasma enhanced chemical vapor deposition (PECVD) in which the silane is reacted with N_2O to form SiO_xN_y. The oxynitride cap layer is then subjected to a low-temperature nitrogen (N_2) anneal to drive off water. Col. 3, lines 53-54.

Li suggests that the cap layer described above suffers certain disadvantages, such as increasing an overall dielectric constant of the ILD layer and introducing difficulties during subsequent etching processes. Col. 3, line 65, through col. 4, lines 16.

Li then proceeds to describe the process shown in FIG. 2 thereof in which the cap layer deposition is omitted in favor of a plasma treatment.

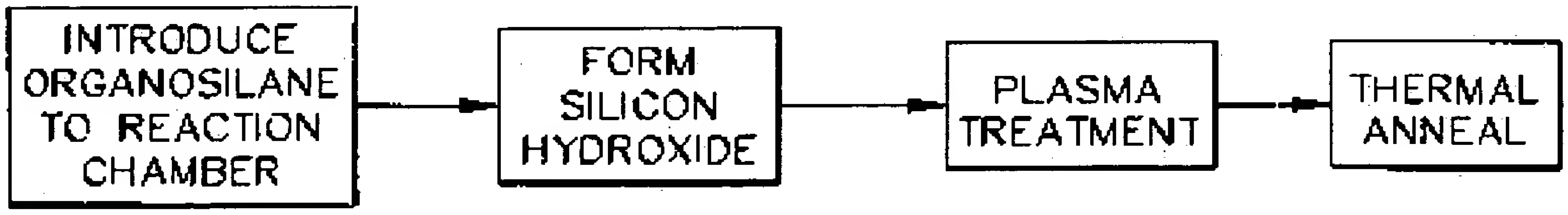

FIG. 2

The first two boxes illustrated in FIG. 2 of Li essentially represent the same processes of the first two boxes illustrated in FIG. 1 of *Li*. In particular, an organosilane (e.g., SiH_3CH_3) is made to react with an oxidizing agent (e.g., hydrogen peroxide) to form a layer of silicon hydroxide containing carbon.

The thus formed silanol/carbon containing layer is then treated with a plasma. *Li* teaches that the plasma treatment preferably includes an oxygen component therein, preferably from source gases such as O_2, O_3, N_2O and/or N_2O/N_2. Col. 5, lines 7-42.

Finally, *Li* teaches that a high-temperature thermal anneal may optionally be conducted either during or after the above-described plasma treatment. Col. 5, lines 43-56.

Li describes the benefit of the post-deposition treatment as follows:

> *"Applicant has found that the post-deposition treatment <u>drives water out of the silanol, leaving a polysiloxane network incorporating carbon-to-silicon bonding</u>. Desirably, the material exhibits many characteristics similar to those of silicon dioxide, but with a <u>lower dielectric constant</u>." (Emphasis added.)*

<u>Tsukune et al.</u>

Tsukune et al. is directed to the formation of a <u>silicon oxide film</u> in which initially a filmy gel containing organic groups (i.e., carbon) is deposited, and then a plasma treatment is carried out to remove the carbon from the film. In particular, Tsukune et al. teaches that organic groups are initially included in the film to achieve planarization of the as-deposited film (the organic groups allegedly enhance fluidity, hence planarization, of the as-deposited film). Once planarization is achieved, the organic groups become unnecessary, and in fact, "undesirable". Thus, Tsukune et al. further teach that an H/O

plasma treatment and/or heat treatment are carried out to remove the organic groups prior to setting of the film. The organic groups may be removed by oxidation reaction or a reduction reaction. See, e.g., col. 12, lines 16-36.

Tamura et al.

This reference is mainly directed to the configuration of a plasma chamber in order to avoid the generation of particulates on an inner wall of the chamber.

It appears that primary relevance to the Examiner of this reference resides in the fact that an RF driven platen electrode is disclosed.

The Examiner's Rejection

The Examiner acknowledges that *Li* fails to teach, among other things, the hydrogen plasma treatment recited each of the appealed claims. To overcome this deficiency in the *Li*, the Examiner attempts to apply the teachings of *Tsukune et al.* In particular, the Examiner states:

> *"Tsukune et al. teach that a thin film of an organic-group-containing silicon oxide deposited on a wafer by plasma CVD from TEOS and oxygen source (See column 11, lines 43-46) can be converted to silicon oxide by subjecting the thin film to a plasma treatment at high temperature by an oxidation reaction using oxygen or a reduction reaction using hydrogen to remove organic groups from the thin film (See column 12, lines 16-27). In other words, Tsukune et al. teach that hydrogen plasma is functionally equivalent to oxygen plasma for converting a film deposited on a wafer by plasma CVD from TEOS and oxygen source to silicon oxide by plasma treatment.*

> *It would have been obvious to one of ordinary skill in the art at the time the invention was made to have used hydrogen plasma instead of oxygen plasma in Li since Tsukune et al. teach that hydrogen plasma is functionally equivalent to oxygen plasma for converting a film deposited on a wafer by plasma CVD from TEOS and oxygen source to silicon oxide by plasma treatment. (Emphasis added).*

The Examiner further acknowledges that *Li* fails to teach, among other things, the use of an RF driven electrode as recited in each of the appealed independent claims 1 and 21, and the use of an RIE plasma mode as recited in independent claim 22. To overcome this deficiency in the *Li*, the Examiner appears to apply the teachings of *Tamura et al.* Admittedly, however, Appellant is not clear as to the exact role Tamura et al. is playing in the subject rejection.

Claims 1 and 21

One of ordinary skill in the art would not modify *Li* in view of *Tsukune et al.* in the fashion suggested by the Examiner.

As admitted by the Examiner, the objective of the hydrogen treatment of *Tsukune et al.* is to remove carbon groups from the film. *Li* has the opposite objective – to retain the carbon and its attendant low-k dielectric properties.

The Examiner contends that *Tsukune et al.* teaches the "equivalence" of hydrogen plasma and oxygen plasma. Appellants are unclear what the Examiner means by this, and can find no such teaching in *Tsukune et al.*

Perhaps more importantly, however, the Examiner seems to ignore the overall context of *Tsukune et al.* That is, *Tsukune et al.* is directed to a process intended to remove all the carbon of the processed film. Further, the plasma treatment of *Tsukune et al.* is explicitly described in connection with extremely thin films (1000Å or less; col.

12, lines 27-32) laid one on top of the other. Any alleged equivalence between hydrogen and oxygen plasma must be taken based on the teachings of *Tsukune et al.* as a whole.

Li intends to retain carbon, and it would not be obvious to look to the plasma treatment of *Tsukune et al.* which intends to achieve the opposite outcome.

Further, as described hereinabove, the plasma process of *Li* is intended to avoid deposition of a separate oxynitride cap layer which is formed by introduction of N_2O gas into the reactor. It is not without coincidence that *Li* teaches that the substitute plasma treatment is carried out using source gases containing nitrogen and/or oxygen. Neither *Tsukune et al.* nor the prior art generally would lead one of ordinary skill to look to hydrogen plasma treatment as a substitute for the oxynitride cap layer that *Li* seeks to omit.

Still further, in addition to retaining carbon, *Li* et al. aims to drive water (H_2O) out of the silanol layer. There is nothing to suggest that hydrogen (H) plasma would be effective in achieving the results intended by *Li*.

In addition, Appellants disagree that one of ordinary skill would modify *Li* to include the RF driven platen electrode of *Tamura et al.*

In the Office Action, the Examiner states:

> *"Tamura et al teach an example of conventional plasma treatment device described with reference to FIG. 12 (See column 1, lines 11-19) where a substrate holder 42 supporting a substrate 41 is capable of controlling temperatures by heating to a specified temperature, and a high-frequency power source 44 is connected to holder 42 so as to apply biased voltage to substrate 41 (See column 1, lines 28-67)."*

> *"Li further teach that the ionizing power can be coupled to the gas not only by RF plasma but also by way of inductively coupled plasma as well (See column 5, lines 24-29). In other words, Li teaches that inductively coupled plasma is functionally equivalent to RF plasma for their use as ionizing power." (Emphasis added.)*

> *"It would have been obvious to one or ordinary skill in the art at the time the invention was made to have used inductively coupled plasma concurrently with RF plasma (in RIE mode) for generating hydrogen plasma in Li in view of Tsukune et al since Li teaches that inductively coupled plasma is functionally equivalent to RF plasma for their use as ionizing power." (Emphasis added.)*

Applicant's are unclear as to what the Examiner means by "RF plasma." ICP plasma and RIE plasma are both generated using RF energy. Further, it is a mystery to Appellant where the Examiner finds support for the passages emphasized above.

In any event, as is well-understood by those of ordinary skill, an RF driven platen electrode is utilized to increase the energy with which the plasma ions are made to contact the surface of a wafer. There is nothing in the references of record which suggest that *Li*'s process should be (or even could be) modified in such a manner, and the Examiner's rejection falls far short of establishing a *prima facie* case of modifying Li in this manner.

Claim 22

The comments presented above regarding independent claims 1 and 21 are equally applicable to independent claim 22. As such, reference is made to those

previous comments.

In addition, the Office Action leaves one with the impression that the Examiner considers ICP and RIE plasma processing to be interchangeable – without regard to what one intends to achieve. As anyone of ordinary skill in the art would attest, RIE plasma processing is a relatively "rough" process (hence, the "etching" descriptive in its name) in which an RF driven platen is utilized to forcibly drive the plasma into the upper surface of the substrate. ICP plasma processing and RIE plasma processing cannot arbitrarily be substituted one for the other as the Examiner seems to believe.

The record is entirely devoid of any teaching which would suggest that RIE plasma processing should be, or even could be, adopted in the processes taught by *Li* and *Tsukune et al.*

Claim 26

This claim recites generation of the hydrogen plasma in an Inductively Coupled Plasma (ICP) mode concurrently with the RIE mode. The references of record are devoid of any teachings of subjecting an organic polymer layer to hydrogen plasma generated in the manner defined by claim 26.

Claims 3, 5, 10-20 and 23-25

The Appellant does not acquiesce that the rejections of dependent claims 3, 5, 10-20 and 23-25 stand and fall together with the rejection of independent claims 1, 21 and 22. However, since the rejections of independent claims 1, 21 and 22 are clearly without merit, and for the sake of brevity, the rejection of these dependent claims is not separately argued with respect to the first rejection under 35 U.S.C. ¶103.

III. TSUKUNE ET AL. IN VIEW OF DOMOTO ET AL., LI AND TAMURA ET AL.

Claims 1, 3, 5, 10-26 stand rejected under 35 U.S.C. ¶103 as being unpatentable over *Tsukune et al.* (US 5,314,724) in view of *Domoto et al.* (US 6,354,008), *Li* (US 6,383,951) and *Tamura et al.* (US 5,897,923).

<u>Li, Tsukune et al. and Tamura et al.</u>

These references have been discussed above in connection with the first rejection under 35 U.S.C. ¶103.

<u>Domoto et al.</u>

Domoto et al. is directed to the fabrication of electric shaver blades, and is apparently relevant to the Examiner in that it discloses that a CVD chamber can include a grounded platen electrode (FIG. 25) or an RF-driven platen (FIG. 29).

<u>The Examiner's Rejection</u>

Appellant simply does not understand this rejection. More precisely, Appellant does not understand the exact manner in which the Examiner is proposing to combine the references, and Appellant does not understand what form the resultant combination is intended to take.

It <u>appears</u> that the Examiner proposes to modify the process of Tsukune et al. by adopting the process conditions of *Li*. For example, the Examiner states:

> *"[I]t would have been obvious to one of ordinary skill in the art at the time the invention was made to have conducted treating of the polymer layer in Tsukune et al. at conditions described by Li depending on particular application with the expectation of providing the desired hardened and*

crosslinked polymer layer, as taught by Li."

Although unclear, it appears the Examiner is relying on Tamura et al. and Domoto et al. to further modify Tsukune et al. to add an RF driven electrode.

Claim 1

One of ordinary skill in the art would not modify *Tsukune et al.* in view of *Li* in the fashion suggested by the Examiner.

Once again, the objective of the hydrogen treatment of *Tsukune et al.* is to remove carbon groups from the film. *Li* has the opposite objective – to retain the carbon and its attendant low-k dielectric properties.

As with the first rejection under 35 U.S.C. ¶103, the Examiner ignores the overall context of *Tsukune et al.* That is, *Tsukune et al.* is directed to a process intended to remove all the carbon of the processed film. Further, the plasma treatment of *Tsukune et al.* is explicitly described in connection with extremely thin films laid one on top of the other.

Li intends to retain carbon, and it would not be obvious to apply the process conditions of *Li* to the plasma treatment of *Tsukune et al.* which intends to achieve the opposite outcome.

In addition, Appellants disagree that one of ordinary skill would modify *Tsukune et al.* to include an RF driven platen electrode. As discussed previously, an RF driven platen electrode is utilized to increase the energy with which the plasma ions are made to contact the surface of a wafer. There is nothing in the references of record which suggest that *Tsukune*'s process should be (or even could be) modified in such a manner, and the Examiner's rejection falls far short of establishing a *prima facie* case of modifying *Tsukune et al.* in this manner.

In the Office Action, the Examiner states:

"It is the Examiner's position that the polymer layer in

> *Tsukune et al. in view of Domoto et al., Li and Tamura et al. would still include some or even traces of carbon (i.e., Si-C bonds) because: (i) it is generally impossible to completely remove every possible Si-C bond; and (ii) the treatment of the deposited polymer layer to remove organic groups (i.e., Si-C bonds) form the polymer layer ... is somewhat milder than the treatment of the claimed invention... ."*

In response, Appellant's respectfully point out that the Examiner has cited <u>no authority whatsoever</u> for the proposition "(i)" that it is "generally impossible" to completely remove every possible Si-C bond. This statement is unsubstantiated, speculative, and not supported by the record.

As for point "(ii)" of the Examiner's comments extracted above, Appellant does not understand what the Examiner is suggesting by use of the word "milder." The process conditions of Tsukune et al. (layer thickness, carbon content, materials, etc.) are far removed from those of the presently claimed invention. Appellant simply cannot respond to this aspect of the Examiner's reasoning without further clarification.

<u>Claim 21</u>

Appellants contend that claim 21 defines over the cited references for the same reasons discussed above in connection with claim 1.

In addition, as suggested previously, *Tsukune et al.* teaches the repetition of alternating steps of deposition of an organic-group-containing silicon oxide film and plasma treatment. Col. 12, lines 27-32. Further, *Tsukune et al.* states:

> *"... a thin film is deposited to a thickness of 100nm [1000Å] or less that is, <u>the upper limit</u> of the depth treatable by means of a plasma is preferably a thickness of 10nm [100Å]*

or less ... ." (Emphasis added.)

It would not be obvious to modify *Tsukune et al.* to treat a layer having a thickness in a range of 7,000Å to 9,000Å as recited in claim 21.

Claims 14 and 25

Tsukune et al. aims to form a silicon oxide layer, and thus teaches away from an organic polymer layer having a dielectric constant of less than 3.00 as recited in claims 14 and 25.

Claim 22

The comments presented above regarding independent claims 1 and 21 are equally applicable to independent claim 22. As such, reference is made to those previous comments.

Once again, the Office Action leaves one with the impression that the Examiner considers ICP and RIE plasma processing to be interchangeable – without regard to what one intends to achieve. ICP plasma processing and RIE plasma processing can not arbitrarily be substituted one for the other as the Examiner seems to believe.

The record is entirely devoid of any teaching which would suggest that RIE plasma processing should be, or even could be, adopted in the processes taught by *Li* and *Tsukune et al.*

Claim 26

This claim recites generation of the hydrogen plasma in an Inductively Coupled Plasma (ICP) mode concurrently with the RIE mode. The references of record are devoid of any teachings of subjecting an organic polymer layer to hydrogen plasma generated in the manner defined by claim 26.

Claims 3, 5, 10-13, 15-20 and 23-24

The Appellant does not acquiesce that the rejections of dependent claims 3, 5, 10-13, 15-20 and 23-24 stand and fall together with the rejection of independent claims 1, 21 and 22. However, since the rejections of independent claims 1, 21 and 22 are clearly without merit, and for the sake of brevity, the rejection of these dependent claims is not separately argued with respect to the second rejection under 35 U.S.C. ¶103.

IV. CONCLUSION

For at least the reasons given herein, Appellant respectfully contends that (a) the Examiner has not established a *prima facie* case of obviousness with respect to the subject matter defined by the appealed claims, and (b) the subject matter of the appealed claims would not have been obvious to one of ordinary skill in view of the teachings of the cited references.

Respectfully submitted,

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March 17, 2006

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CLAIMS APPENDIX

1. A method of processing a polymer layer including Si-C bonds including the steps of heating the layer to desorb moisture and harden the layer and exposing the layer to a hydrogen plasma during the heating process, wherein the polymer layer includes carbon subsequent to said heating and exposing, and wherein the layer is supported on an electrode and the plasma is at least partially maintained by an RF power source connected to the electrode.

3. A method as claimed in Claim 1 wherein the plasma is present throughout the heating stage.

5. A method as claimed in Claim 4 wherein the power source is between 400 and 750 watts.

10. A method as claimed in Claim 1 wherein the heating step lasts for between 2 and 4 minutes.

11. (original): A method as claimed in Claim 10 wherein the heating step lasts for 3 minutes.

12. A method as claimed in Claim 1 wherein the layer is heated to between 350°C and 550°C.

13. A method as claimed in Claim 1 wherein:
(1) the power source provides substantially 600 watts;
(2) the platen is heated to between 400°C and 500°C; and
(3) the heating step lasts for substantially 3 minutes.

14. A method as claimed in Claim 1 wherein the dielectric constant of the processed layer is below 3.00.

15. A method as claimed in Claim 1 wherein the layer is treated by the plasma to depth >3000Å.

16. A method as claimed in Claim 1 wherein the layer is treated by the plasma to a depth of <600Å.

17. A method as claimed in Claim 1, wherein the layer is an insulating layer on a semiconductor wafer.

18. A method as claimed in Claim 1, wherein the processing method reduces cracking in the layer.

19. A method as claimed in Claim 1, wherein the processing method improves the wet etch rate of the layer.

20. A method as claimed in Claim 1, wherein the polymer layer includes Si-C bonds subsequent to said heating and exposing.

21. A method of processing a polymer layer including Si-C bonds including the steps of heating the layer to desorb moisture and harden the layer and exposing the layer to a hydrogen plasma during the heating process, wherein the plasma is at least partially maintained by an RF driven electrode on which the layer is supported, wherein the polymer layer includes carbon subsequent to said heating and exposing, and wherein a thickness of the layer is in a range of 7,000Å to 9,000Å.

22. A method of processing a polymer layer including Si-C bonds, comprising:

heating the layer to desorb moisture and harden the layer; and

exposing the layer to a hydrogen plasma during the heating process, wherein hydrogen plasma is generated in a Reactive Ion Etching (RIE) mode;

wherein the polymer layer includes carbon subsequent to said heating and exposing.

23. A method as claimed in Claim 22, wherein said heating and exposing occurs for 60 to 300 seconds.

24. A method as claimed in Claim 22, wherein the layer is supported by a platen, and wherein the platen temperature during said heating is 350°C to 500°.

25. A method as claimed in Claim 22, wherein the dielectric constant of the processed layer is less than 3.00.

26. A method as claimed in Claim 22, wherein hydrogen plasma is further generated in an Inductively Coupled Plasma (ICP) mode concurrently with the RIE mode, wherein the layer is supported by a platen, and wherein the platen temperature during said heating is 400°C to 500°.

EVIDENCE APPENDIX

Extract From U..S. patent no. 6,100,184

METHOD OF MAKING A DUAL DAMASCENE INTERCONNECT STRUCTURE USING LOW DIELECTRIC CONSTANT MATERIAL FOR AN INTER-LEVEL DIELECTRIC LAYER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of semiconductor wafer processing and, more particularly, to a technique for fabricating a dual damascene interconnect structure in which low dielectric constant dielectric layers are used for the inter-level dielectric.

2. Background of the Related Art

In the manufacture of devices on a semiconductor wafer, it is now the practice to fabricate multiple levels of conductive (typically metal) layers above a substrate. The multiple metallization layers are employed in order to accommodate higher densities as device dimensions shrink well below one micron design rules. Likewise, the size of interconnect structures will also need to shrink, in order to accommodate the smaller dimensions. Thus, as integrated circuit technology advances into the sub-0.25 micron range, more advanced interconnect architecture and new materials are required.

One such architecture is a dual damascene integration scheme in which a dual damascene structure is employed. The dual damascene process offers an advantage in process simplification by reducing the process steps required to form the vias and trenches for a given metallization level. The openings, for the wiring of a metallization level and the underlying via connecting the wiring to a lower metallization level, are formed at the same time. The procedure provides an advantage in lithography and allows for improved critical dimension control. Subsequently, both the via and the trench can be filled utilizing the same metal-filling step, thereby reducing the number of processing steps required. Because of the simplicity of the dual damascene process, newer materials can now cost-effectively replace the use of the existing aluminum/SiO_2 (silicon dioxide) scheme.

One such newer material is copper. The use of copper metallization improves performance and reliability over aluminum, but copper introduces additional problems which are difficult to overcome when using known techniques for aluminum. For example, in conventional aluminum interconnect structures, a barrier layer is usually not required between the aluminum metal line and an SiO_2 inter-level dielectric (ILD). However, when copper is utilized, copper must be encapsulated from the surrounding ILD, since copper diffuses/drifts easily into the adjoining dielectric. Once the copper reaches the silicon substrate, it will significantly degrade the device's performance.

In order to encapsulate copper, a barrier layer of some sort is required to separate the copper from the adjacent material (s). Because copper encapsulation is a necessary step requiring a presence of a barrier material to separate the copper, other materials can now be substituted for the SiO_2 as the material for ILD. Replacing the SiO_2 by a low-dielectric constant (low-∈) material reduces the interline capacitance, thereby reducing the RC delay, cross-talk noise and power dissipation in the interconnect. However, it is generally necessary to have a barrier (or liner) present between the interconnect and the low-∈ ILD to prevent possible interaction between the interconnect and the low-∈ ILD and also to provide adhesion between them. This barrier is desirable even when aluminum is utilized for the interconnect.

There are generally two types of low-∈ films for integrated circuit applications. One group is comprised of the modified SiO_2 materials, such as fluorinated oxide (add limited F into SiO_2) and silsesquioxane (add limited H or C-based organic elements to SiO_2). The other group is comprised of the organic materials, such as polyimides and polymers, having completely different molecular structures in comparison to SiO_2. One advantage of organic low-∈ films is that they offer a lower dielectric constant than the modified SiO_2 materials.

One known technique of utilizing organic low-∈ dielectric material for damascene interconnect is described in "Planar Copper-Polyimide Back End Of The Line Interconnections For ULSI Devices;" B. Luther et al.; 1993 VMIC Conference; Jun. 8–9, 1993; pp. 15–21. However, the technique described is for a single damascene process. The present invention describes the use of low-∈ dielectric material in a dual damascene process for use as an ILD.

SUMMARY OF THE INVENTION

The present invention describes a technique for fabricating a dual damascene interconnect structure using a low dielectric constant material as a dielectric layer or layers. A low dielectric constant (low-∈) dielectric material is used to form an inter-level dielectric (ILD) layer between metallization layers and in which via and trench openings are formed in the low-∈ ILD. The dual damascene technique allows for both the via and trench openings to be filled at the same time. In the preferred embodiment, an organic low-∈ dielectric material is selected.

A dielectric separation layer is deposited over an underlying conductive region, which can be another interconnect or a doped region. Next, a first low-∈ dielectric ILD layer is deposited followed by a first dielectric etch-stop layer. Then, a via window is formed in the first etch-stop layer. Subsequently, a second low-∈ dielectric ILD layer is deposited, followed by a second dielectric etch-stop layer. Next, a trench window is formed in the second etch-stop layer.

In the preferred embodiment, the low-∈ layers are formed from an organic material. The two etch-stop layers are comprised of a different material from the dielectric separation layer, in order to allow for high etch selectivity. The low-∈ dielectric ILD layers are anisotropically etched to remove the low-∈ material under the openings. The etching step etches the low-∈ material to form the via and trench openings. Next, the exposed portion of the first dielectric layer at the bottom of the via opening is etched to expose the underlying conductive region.

Subsequently, the via and trench openings are filled with a conductive material. With the preferred embodiment, a conformal barrier or encapsulation layer is first deposited, followed by a metal fill, such as copper or aluminum. Chemical-mechanical polishing is then utilized to polish away the excess metal residing above the trench region.

In an alternative embodiment, when copper is used for metallization, a selective deposition process is employed on the underlying interconnect. The selective deposition of a barrier material allows for a formation of a barrier cap only over the exposed copper, so that the blanket deposition of the dielectric separation layer is not needed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a conductive region formed within a dielectric layer and in which an interconnect

RELATED PROCEEDINGS APPENDIX

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